developer, and the amount chanced to be correct. All photography is done with objective and camera. In photographing the sun, the object is some ninety millions of miles off; in photographing a fluid inclusion in quartz, it is the 1/16th of an inch off—a mere question of detail. Most of these scientific photographs are far easier than the simplest everyday landscape.

A. R. HUNT.

Comets and Corpuscular Matter.

REFERRING to Prof. J. J. Thomson's article on "corpuscles" in your issue of May 10, it occurs to me that the behaviour of corpuscular matter described therein may have some bearing on cometary phenomena. May not the structure of comets to some extent be explained by assuming that their tails are composed of aggregations of negatively charged particles of extremely minute size, answering to the free corpuscular matter as defined by Prof. Thomson, and which to a large degree may be formed by a sort of "corpuscular dissociation," or detachment, taking place in the comet's nucleus when its temperature is elevated upon nearing the sun? Since Prof. Thomson's experiments indicate the presence of negatively charged matter in kathode rays having a much smaller mass than ordinary atoms, there is reason to believe that matter in this state has properties quite apart from matter in a much coarser state of atomic division. Postulating an electrostatic field as existing in interplanetary space, with the sun as a negative centre or source of electrostatic radiation, and assuming that a comet's tail is composed of these corpuscles, the gravitational force it may suffer, when in proximity to the sun, would perhaps be very small in comparison with the electrostatic force existing throughout the vast congregation of these extremely minute particles, and thereby account for the repulsion of the tails of comets when they approach the sun.

The nuclei of comets may be composed of matter in a much coarser state of subdivision, which, though endowed with positive or opposite electricity, is subject to gravitational influences which determine their course in the neighbourhood of the sun.

While the above is a partial re-statement of existing hypotheses, it may, I venture to suggest, be of interest in connection with Prof. Thomson's remarkable experiments on matter smaller than atoms.

F. H. LORING.

1 Champion Grove, Denmark Hill, S.E., May 18.

A NEW INSTRUMENT TO MEASURE AND RECORD SOUNDS.[1]

A DIRECT, absolute measurement of the intensity of sound at any point in the air must determine in ordinary units, such as kilogram-metres, the energy involved in the condensations and rarefactions of which the propagation of sound consists. But these pulsations follow each other so rapidly, and the amount of energy involved in even the loudest sound is so infinitesimal, that such measurement is attended with considerable difficulty; so much, indeed, that probably not a half-dozen laboratories in the world have any instrument whatever purporting to make direct, absolute measurements of the energy of sound.

We owe to Helmholtz ("Wissenschaftlische Abhandlungen," vol. i. p. 378) a mathematical theory by which we can determine the ratio between the energy of the pulsations of a tone just without, and that within a spherical Helmholtz resonator; to Lord Rayleigh we owe an expression for the energy of sound in terms of the condensation ("Theory of Sound," vol. ii. Sec. 245). Upon these two results this instrument (like Wien's, *Wied. Ann.* 1898, p. 834) is founded.

A pure tone is received into a spherical Helmholtz resonator, a portion of the walls of which is replaced by a small, circular, extremely thin glass plate, situated just opposite the mouth of the resonator. The pulsations within force this plate to vibrate with the tone's frequency; and if the natural pitch of the plate is made to approximate that of the resonator and tone, the amplitude of the plate's vibrations are rapidly multiplied. To make this amplitude a definitely measurable quantity, the sensitive plate carries at its centre a tiny mirror, which forms one of a system of mirrors constituting Michelson's refractometer (*Phil. Mag.* 1882, xiii. p. 236). A displacement of the little mirror from its position at rest amounting to a half wave length of light will cause a corresponding shifting to one side of the interference bands, so that each dark band will take the position before occupied by the next dark band. The width of the bands may be so adjusted that a telescope with micrometer eyepiece can easily subdivide each band into a hundred parts. Hence the displacement of the sensitive plate, while a tone is sounding, could be observed with great precision, if the eye could act with sufficient rapidity to mark the oscillation of any one band.

That, of course, is out of the question. But it is easy to compound this motion of the bands with another motion perpendicular to it (also in the focal plane), and thus to make the displacements visible. To do this, the interference bands are made to stand vertically in the field, and a screen with a narrow, horizontal slit is interposed in the line of sight; consequently the bands during silence appear in the telescope as a narrow, horizontal strip, composed of the bands reduced to square spots of dark and light. Now a small lens, forming the object-glass of the telescope, is mounted upon the end of one tine of a tuning fork, electrically driven, and having the pitch of the tune to be measured. During silence, the vertical vibration of the object-glass stretches out the strip of spots into a rectangle of long, vertical bands. But when the tone sounds, these bands arrange themselves diagonally across the same rectangle, the slope of the bands increasing with the intensity of the tone.

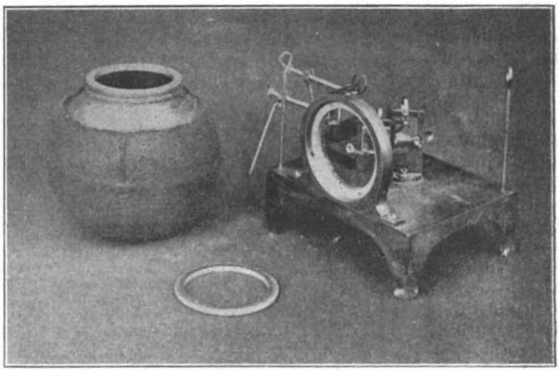

FIG. 1.—The refractometer. The resonator has been unscrewed from the supporting bracket, leaving the sensitive plate and tiny mirror in place.

The micrometer eyepiece can be rotated on its optical axis, and it is provided with a tangent screw for close adjustment. As it is rotated a vernier moves over a graduated arc, so that the angle of the slope (α) may be measured, as well as the height (Q) of the rectangle, the height (o) of the strip, and the width of five double bands. Putting $B = Q - o$, and $P =$ the displacement of a band, we have $P = B \tan \alpha$. The intensity of the tone is proportional to P^2, which is thus determined in mean wave-lengths of white light.

Thus far it has been tacitly assumed that the source of tone is at just the right distance from the receiving resonator for the vibrations of the sensitive plate to be in phase with those of the fork carrying the object-glass. But in ordinary work this agreement in phase

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[1] This instrument is described somewhat more fully than it is here in the *Monthly Weather Review*, July 20, 1899, published by the U.S. Department of Agriculture. We are indebted to the courtesy of its editor, Prof. Cleveland Abbe, for the accompanying illustrations.